Impact of soil dust aerosols upon weather and climate

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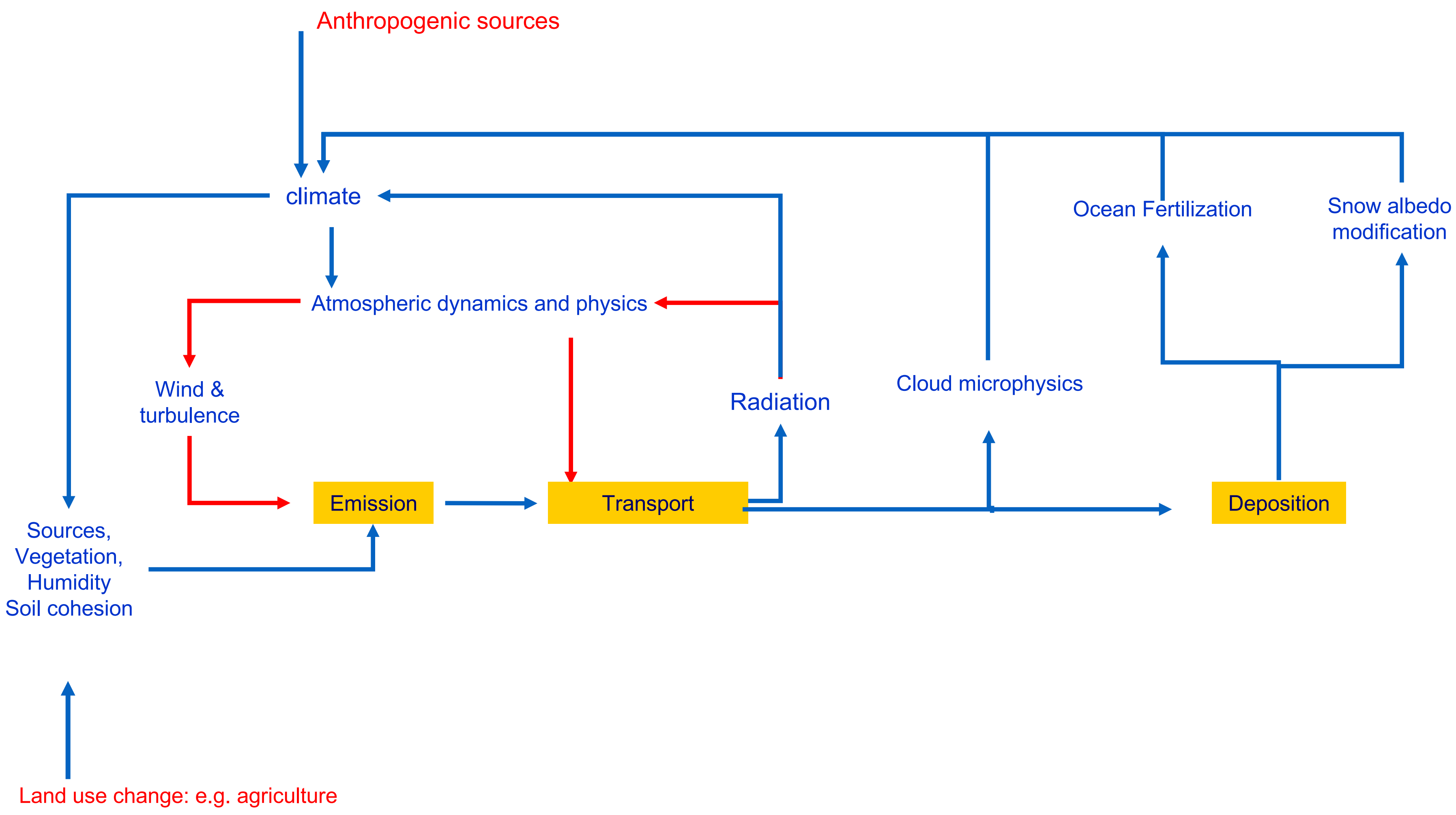
2ND WMO WORKSHOP ON OPERATIONAL CLIMATE PREDICTION
30 May - 1 June 2018, Barcelona, Spain

Dust effects and feedbacks



Today

Forecast/prediction horizons: short-medium range to multi-decadal

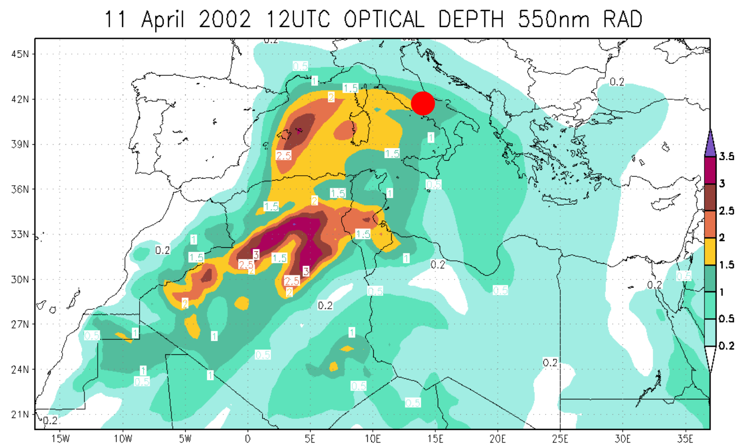
Climatology vs Prognostic aerosols

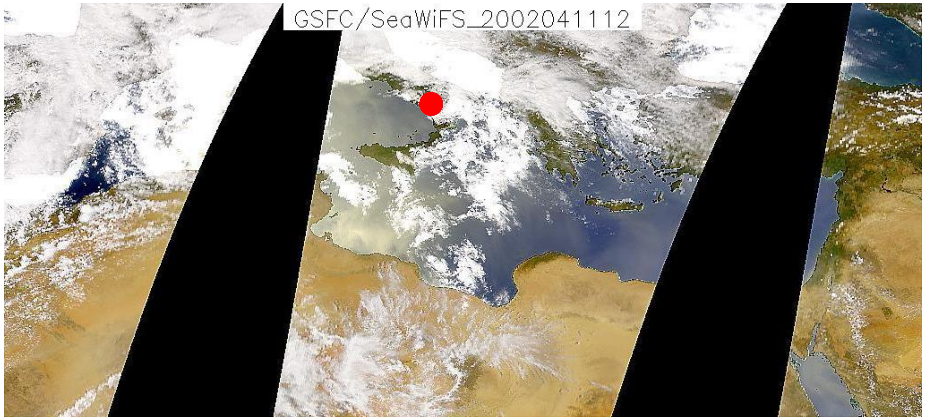
Dust variability: winds, precipitation, vegetation, land use change

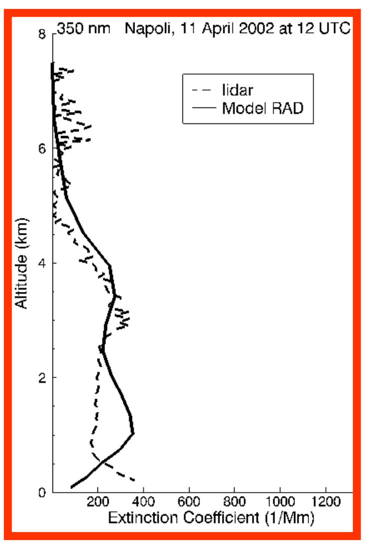
Uncertain dust optical properties

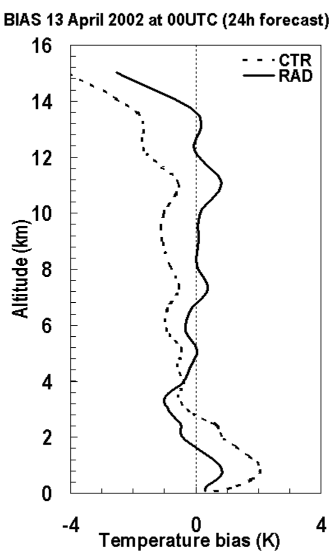
Benefits of dust in short range forecasts?

Pérez et al. 2006









● *Napoli Raman Lidar*

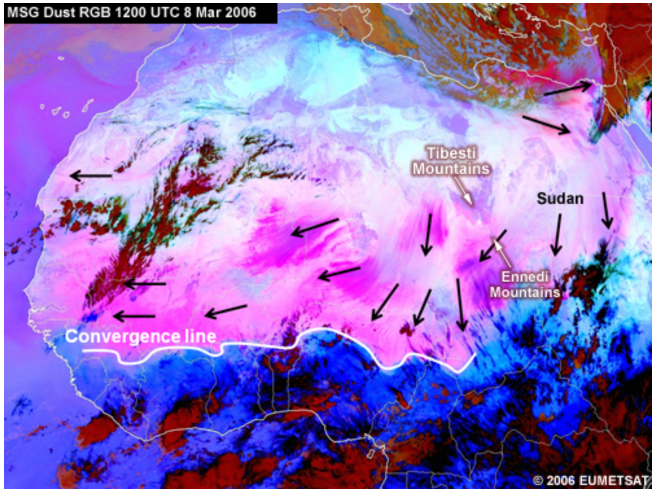
<u>Issues:</u>

Prognostic dust (aerosols) superior to climatology overall?
Not clear

Small errors in the dust plume location and intensity may induce double penalty errors in the effects
Ensembles and dust data assimilation should help

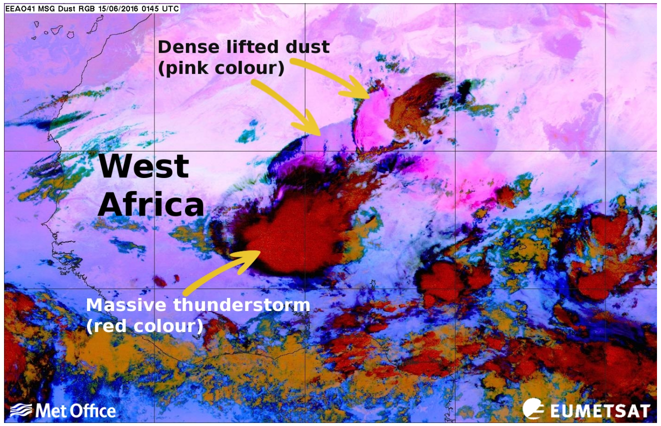
Is it worth the cost compared to other model upgrades, e.g., model resolution?

Short-medium range dust variability and forecast skills



Synoptic dust storms

- Prefrontal winds
- Postprontal winds
- Large-scale Trade winds
- …



Mesoscale dust storms

- Downslope winds
- Gap flow
- Convection (dust devils and Haboobs)
- Inversion downburst storms
- …

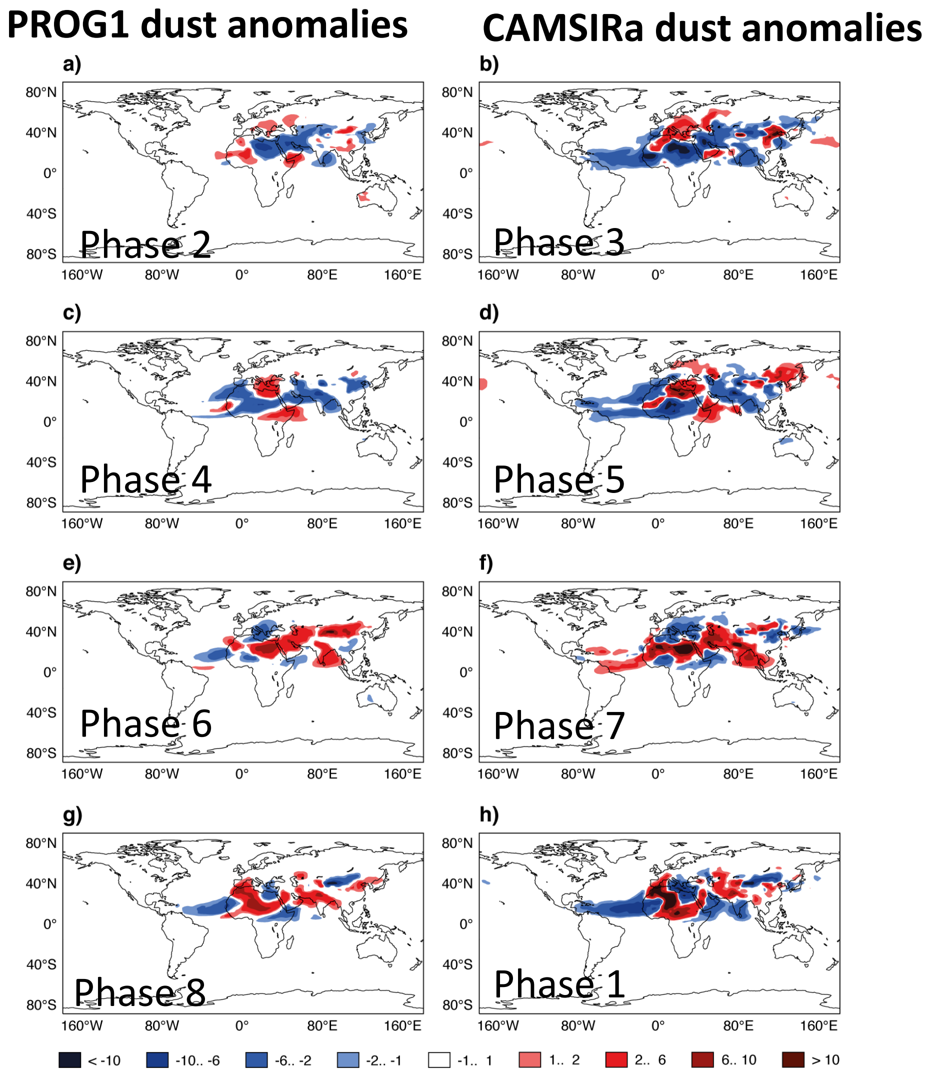
Benefits of dust (and aerosols) in sub-seasonal forecasts

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Courtesy Angela Benedetti and Frédéric Vitart

PROG1 Prognostic aerosols initialized with CAMS Interim Reanalysis
PROG2 Prognostic aerosols initialized with average aerosol state from a free-running model simulation
CONTROL1 Tegen et al. 1997 Climatology
CONTROL2 Bozzo et al. 2017 Climatology

Courtesy Angela Benedetti and Frédéric Vitart

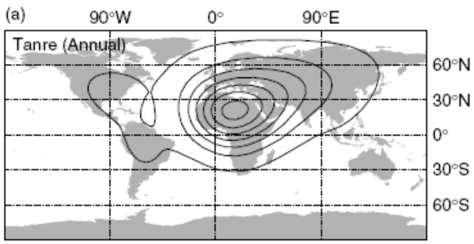


Active MJO phases

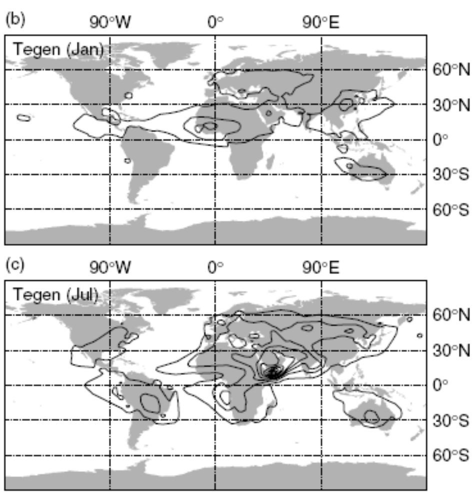
- MJO modulation of aerosol fields seems the most likely mechanism through which this aerosol impact is delivered as it explains most of the aerosol variance at the monthly scale.
- Prediction of aerosol fields at the monthly scales is possible and show a good degree of skill.

Benefits of dust (and aerosols) in seasonal forecasts

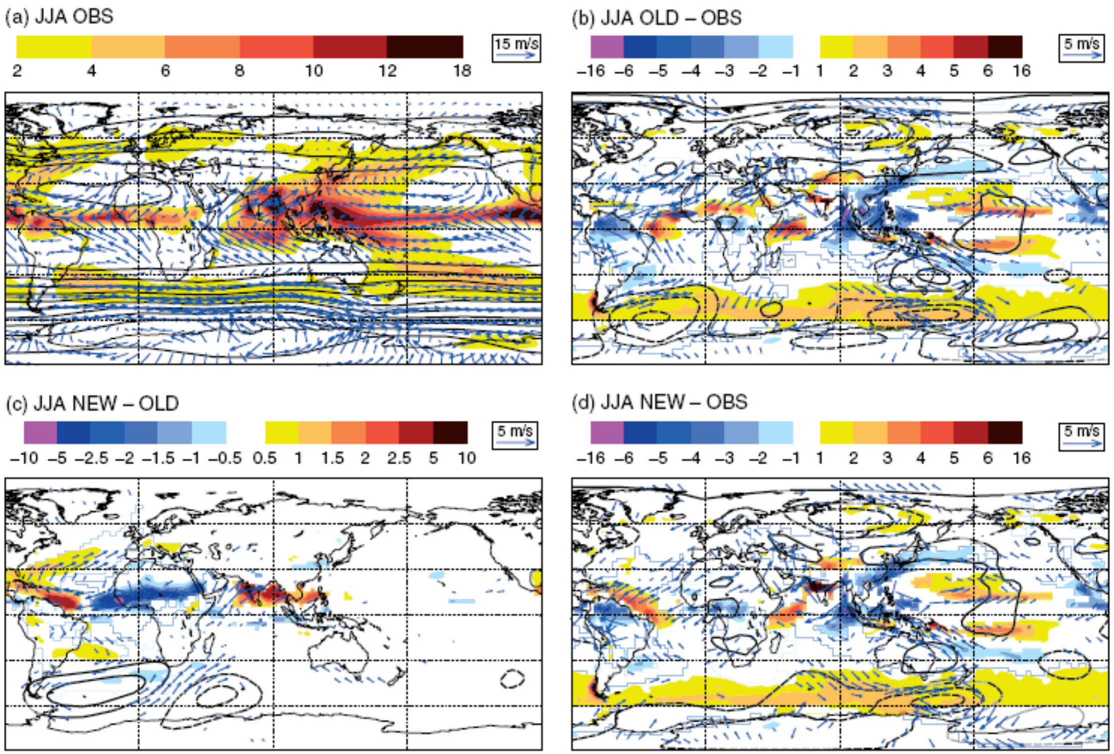
Rodwell and Jung (2008)



Updating aerosol climatologies



Seasonal integrations for 40 December–February and June–August seasons for the period 1962 to 2001.

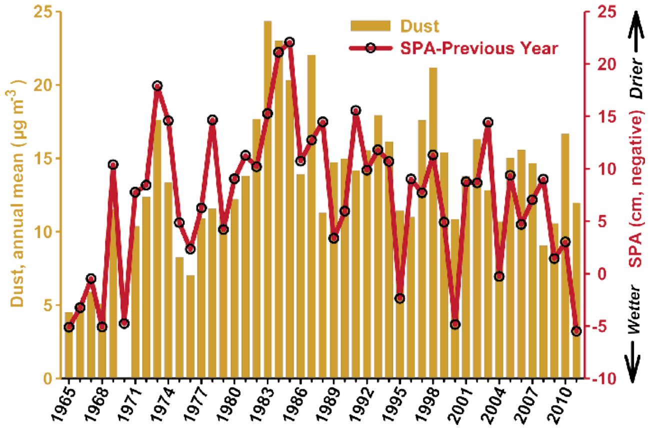


Significant improvements in mean model errors of precip, winds and geopotential height

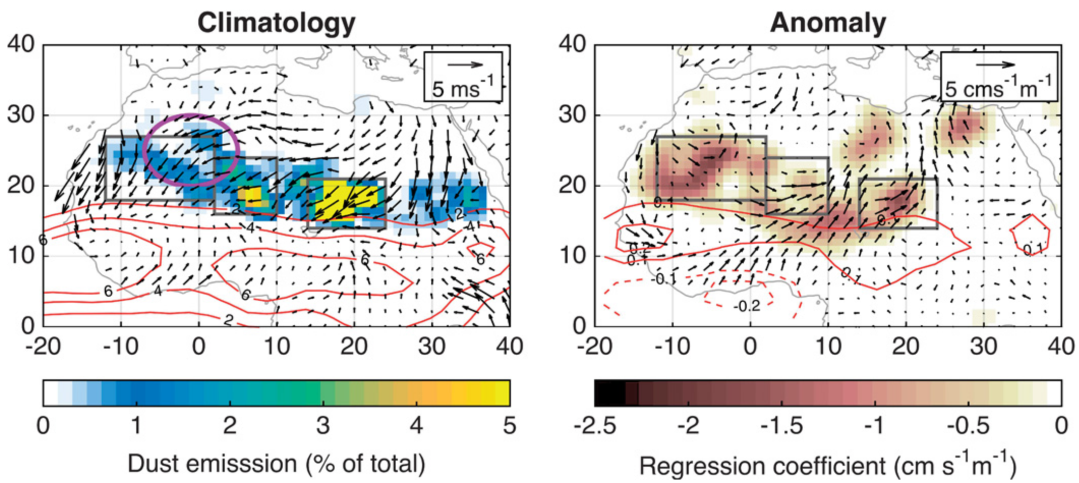
Seasonal dust prediction possible/skillful?

Variability at seasonal and longer time scales
The vegetation vs wind discussion

Sahel June-October Precipitation Anomalies (SPA)



Prospero, 2014



Wang et al., 2015

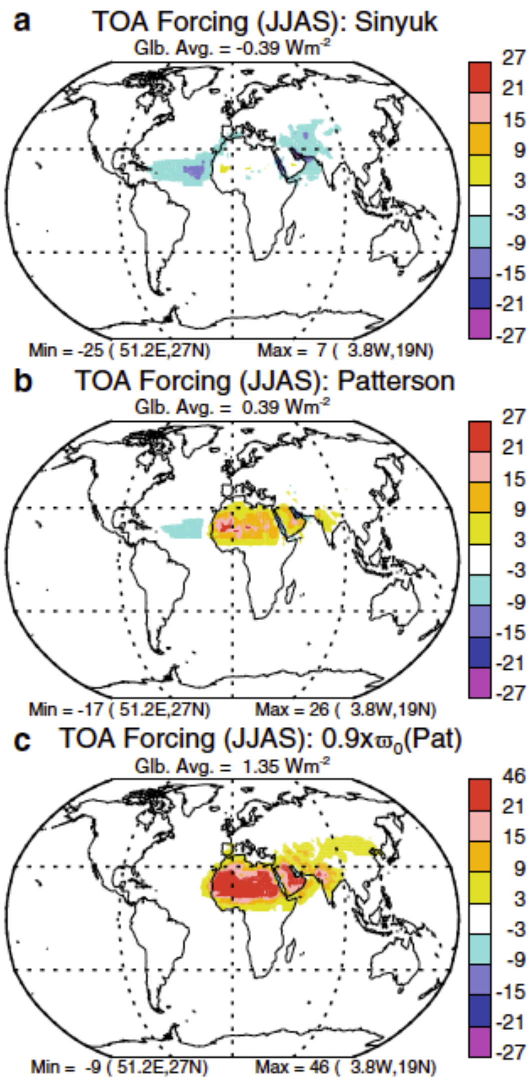
Uncertain optical properties (absorption/scattering)

Miller et al., 2014

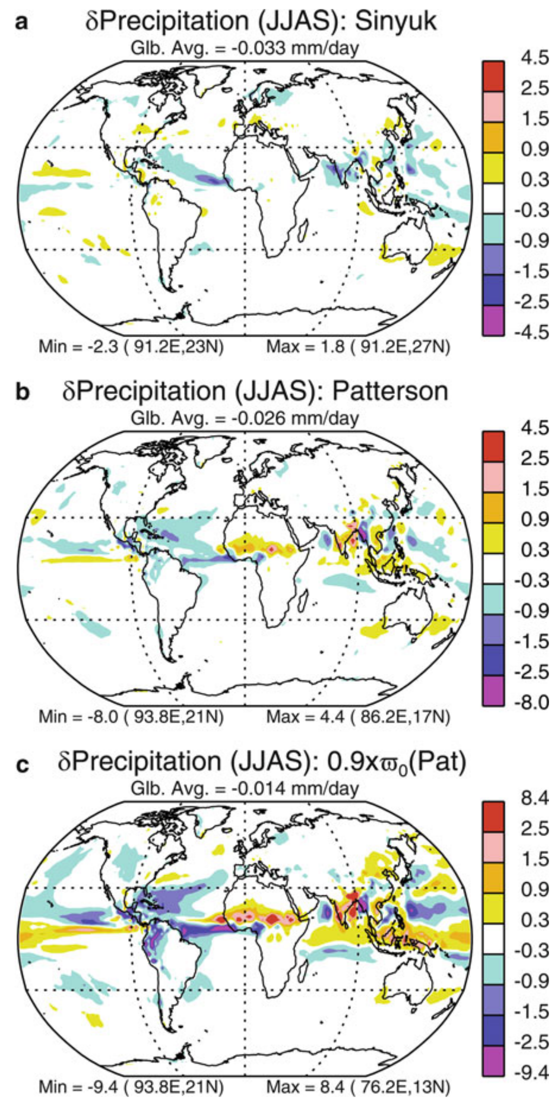
More scattering

More absorption

TOA forcing

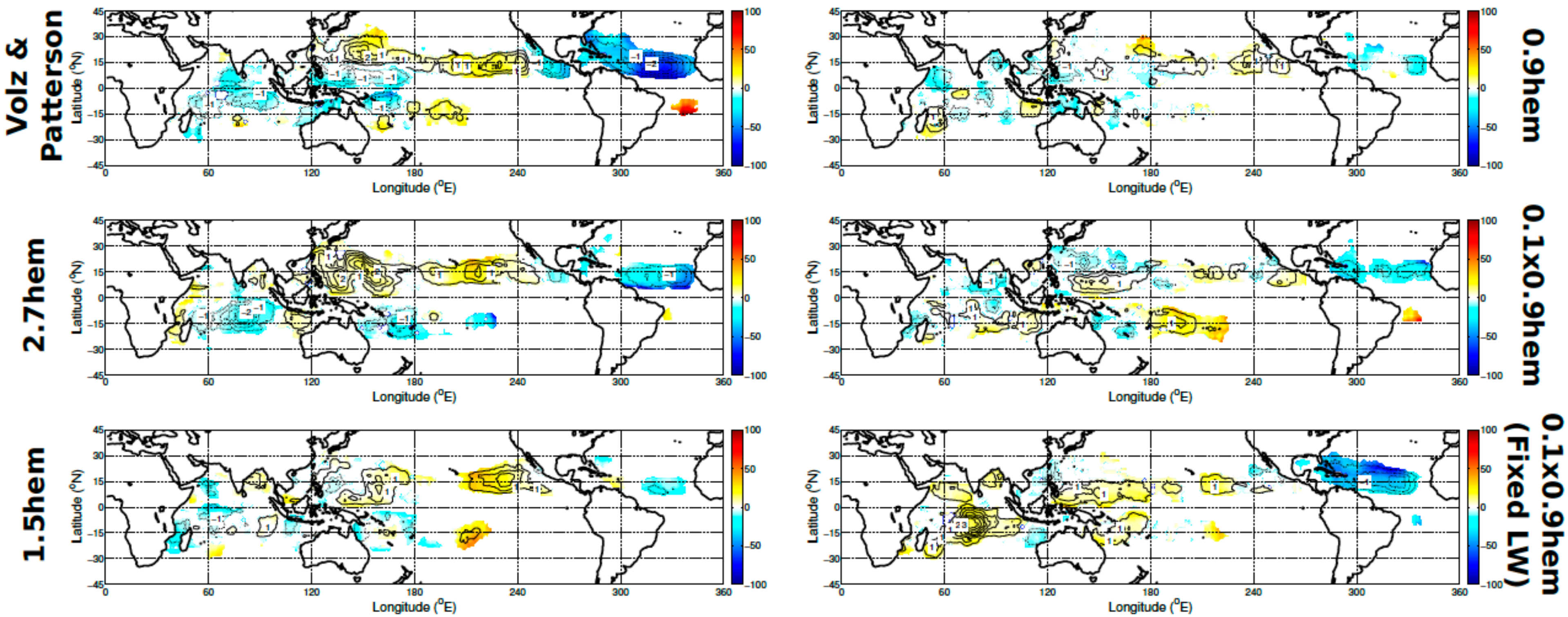


Precipitation response



Tropical Cyclone Track Density changes between 60's and 90's
Strong et al., 2018 in press

Shading: % changes
Contours: day/year



Courtesy Paul Ginoux

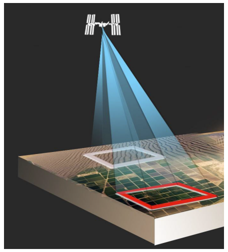
FRAGMENT: FRontiers in dust minerAloGical coMposition and its Effects upoN climaTe

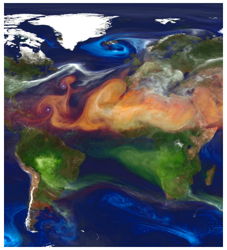
OBJECTIVES

- **FRAGMENTation of soil aggregates:** We will contribute new fundamental understanding in the emitted dust PSD and mineralogy and its relationship with the parent soil based on an unprecedented ensemble of coordinated measurement campaigns and laboratory analyses.

- **Global soil mineral content:** We will evaluate and use currently available airborne and spaceborne hyperspectral imaging to anticipate the coming innovation of retrieving soil mineralogy through high-quality spaceborne hyperspectral measurements (NASA´s EMIT).

- **Role of mineralogy upon radiation, chemistry and clouds:** We will generate integrated and quantitative knowledge regarding the influence of dust mineral composition upon atmospheric radiation, chemistry and clouds based on modelling experiments constrained with our theoretical innovations and field measurements.





Experimental campaigns in Aragon (Spain), Zagora (Morocco) and the Salton Sea (US).

Supporting NASA´s Earth Surface Mineral Dust Source Investigation (EMIT)

Key points

Benefits of prognostic aerosols in sub-seasonal forecasts

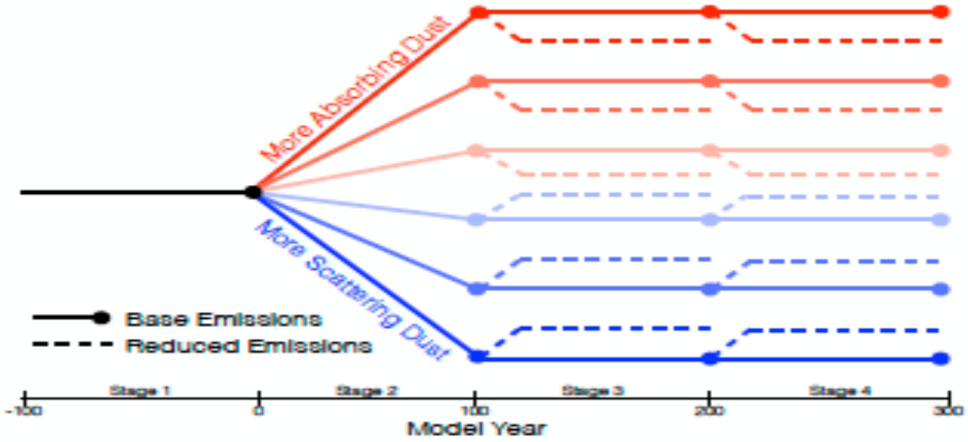
These benefits decrease when compared with more accurate/recent climatologies

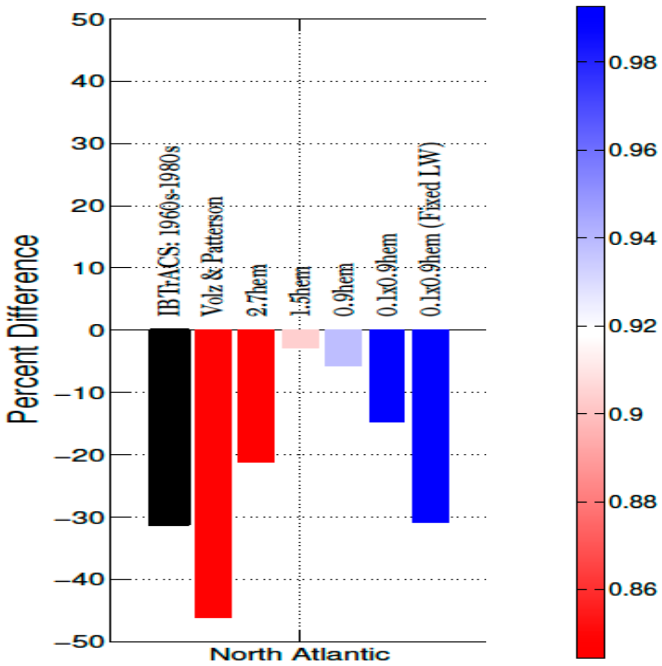
Negative impact of initialization with reanalysis compared with a mean aerosol state initialization

Seasonal predictions significantly improve with updated climatologies

Lack of capabilities/skill in seasonal dust forecasts in addition to vegetation/wind controls; needs much more research

Dust optical properties are key and uncertain; constraining them regionally may have a larger benefits than prognostic seasonal fields at a much smaller cost


More Absorbing Dust
More Scattering Dust
Base Emissions
Reduced Emissions
Stage 1
Stage 2
Stage 3
Stage 4
-100
0
100
200
300
Model Year


Percent Difference
50
40
30
20
10
0
−10
−20
−30
−40
−50
IBTrACS: 1960s-1980s
Volz & Patterson
2.7hem
1.5hem
0.9hem
0.1x0.9hem
0.1x0.9hem (Fixed LW)
North Atlantic
0.98
0.96
0.94
0.92
0.9
0.88
0.86